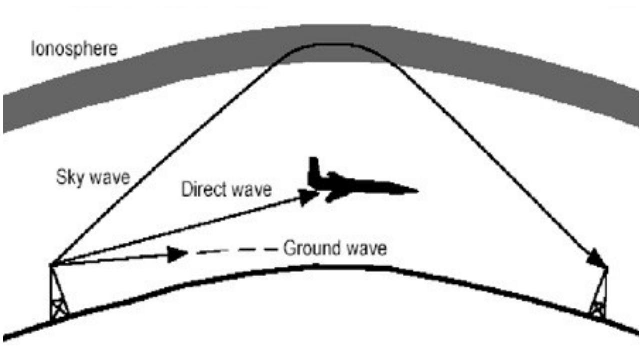
Brass Tacks

An in-depth look at a radio-related topic

Skywave propagation

Every so often I need to make a quick test of an HF (high frequency) setup, such as an antenna or radio or tuner, so I call out to somebody within line-of-sight of my antenna. This is known as *groundwave propagation*, so-called because the signal of greatest interest is relatively close to the ground, in that it's able to go directly from my antenna to that of the target without having to travel way up into the atmosphere.

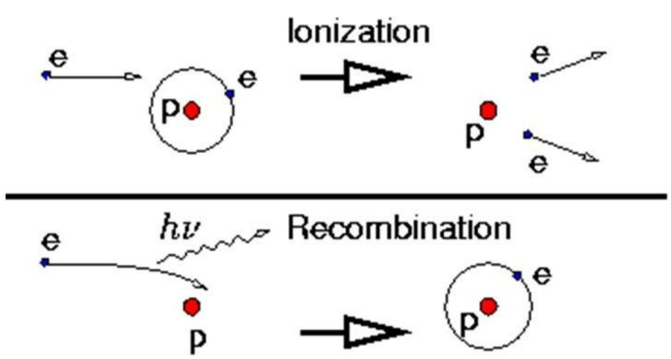


On the other hand, *skywave propagation*, also called *skip*, is communication by RF (radio frequency) waves that *refract* through the atmosphere, and reflect off the surface of the earth. This means, depending on its frequency, it's possible for a radio wave to leave your antenna, bounce off the sky, then reach a station way over the horizon. Or bounce off the sky, bounce off the ground, bounce off the sky, and then reach an even farther station.

But wait, does that mean it's possible for a radio wave to travel up to the sky, back down, then back up, etc., until it eventually arrives back where it started from? Yes, but the *conditions* need to be pretty good for that unlikely event to happen. Before we get into that, let's explore just how it is that radio waves are able to do all this bouncing around, and remain intact enough to carry intelligent information all that distance.

One effect of the Sun on our atmosphere

The phenomenon of skywave propagation starts at the center of the solar system. Without the Sun, radio waves couldn't bounce off the atmosphere the way we need for long-distance communication. Then again, without the Sun we'd all be frozen popsicles anyway, and all that ham radio gear would just sit useless for billions of years. Among other things, the Sun gives off a lot of ultraviolet (UV) light (and other radiation, such as X-rays) in all directions, some of which make their way toward the Earth.



When UV light strikes a Nitrogen or Oxygen molecule in our atmosphere, it *ionizes* it by forcing the molecule to expel an electron, due to the inherent energy ($\mathbf{E} = h\nu$) of the radiation. If an ionized molecule then encounters a free-floating electron, it absorbs the electron in a process called *recombination*, and the molecule returns to its normal state. During the short time an electron is wandering freely, its dominantly negative electric field can actually cause RF radiation that reaches it to bend, or *refract* a little, due to quantum mechanics that are beyond the scope of this article.

Brass Tacks

continued

Where the molecule and the electron could remain apart from each other long enough, that portion of atmosphere holding many ionized molecules and free electrons acts like a mirror to radio waves. In fact, the thinner the atmosphere, the longer the molecules could exist in an ionized state before encountering an electron to recombine with. This high, thin atmosphere rich in free electrons and ionized molecules is known as the *ionosphere*. Down in the lower atmosphere, such as the troposphere and stratosphere, the recombination occurs so quickly, that radio waves don't find many free electrons to create a sufficient field that provides effective refraction.

The difference is day and night

During daylight, UV and X-ray radiation from the Sun strikes the ionosphere very heavily, resulting in an atmospheric shell of multiple *strata*, or layers. Labeled D, E, F1, and F2, these four primary layers are identified by the behavior of radio waves at various frequencies. Most noticeable is the D layer to radio listeners of AM broadcast, shortwave, and amateur HF frequencies, whose signals are almost completely absorbed by this layer. At sunrise, distant stations of these frequencies disappear, only to return at sunset.

At night, the D layer disappears, the E layer weakens, and the F1 and F2 layers seem to combine into a single layer. This allows you to communicate with distant low-frequency stations almost undisturbed. Even though the ionosphere receives no sunlight overnight, and therefore no direct solar UV and X-ray radiation, it has received enough ionizing energy during the day to maintain its radio reflectivity due to the sparseness of its ionized atomic Oxygen.

How sunspots play a role

Remember that UV and X-ray radiation from the Sun are primarily responsible for the existence of the ionosphere and its terrific reflecting properties to radio waves. It just so happens that the areas on the surface of the Sun surrounding sunspots eject enormous amounts of UV and X-ray radiation. Their extra shots of high-frequency radiation enhance our ionosphere, resulting in many happy ham radio operators across the globe. Therefore, the reflectivity of the ionosphere is related to the sunspot cycle.

Back to you

Now you can see how it is that you can transmit a radio wave up to space, refract it through the ionosphere, then reach a contact in another country. But radio waves can also reflect off the surface of the Earth, allowing you to make a contact by several bounces, or *hops*, off the Earth and the ionosphere repeatedly. It's even possible to contact a station located *more* than halfway around the world, an operation known as *long-path*. But how do you know you're working long-path? Because your beam antenna is pointed in the opposite direction from where your contact should normally be located.

So, is it possible to send your signal all the way around the world? Yes, but location, geomagnetic storms, solar flares, time of day, season of the year, and foul weather can get in the way of your contact. Besides, there are easier ways to talk with yourself.

— Noji Ratzlaff, KNØJI (kn0ji@arrl.net)